areas is critical. By using this process with standard shadow-masking and lithography techniques, such patterned catalyst deposits can be created for the development of applications.

Finally, for most applications, the nanotubes need to be produced free of impurities and contamination. The two major sources of contamination in the growth of carbon nanotubes are the buildup of amorphous carbon from the extraneous decomposition of carbon feed gas and contamination by an extraneous metal catalyst. The elimination of the extraneous metal catalyst is currently being accomplished by optimizing the catalyst formula, thus reducing the quantity of "inactive" catalyst. The removal of the amorphous carbon is being realized by the use of etching gases that preferentially remove the amorphous carbon while not damaging the carbon nanotubes.

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Low-Temperature Multiplexing Readouts for Airborne Astronomy

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Cryogenic readouts are the critical electronics for infrared (IR) detector arrays and, in most instances, the dominant source of noise in an IR detection system. Various designs have been developed and perfected over years to minimize the read noise and optimize the circuitry for particular detector arrays for which the readouts are intended to be used. The present effort in this area—to develop readouts that operate at 2 kelvin and achieve improved sensitivity—is driven by the NASA charter to provide state-of-the-art IR technology to the astronomical community at large.

The simplest unit-cell design is the source follower per detector, which employs a single metal-oxide-semiconductor field-effect transistor (MOSFET) in the source follower configuration to read the detector signal. Although the simplicity of this design is attractive in terms of fabrication, minimal use of electronics real estate, and operation, it suffers from the inherent drawback that the integrated charge at the MOSFET gate debiases the detector and thereby degrades the detector linearity. In extreme cases, it can significantly diminish the detector photocurrent. Detector debiasing could pose severe limitations for detector arrays that require low bias levels, such as those used in the far-IR. A capacitive transimpedance amplifier (CTIA) is one possible solution. This design uses a transistor in an amplifier mode and includes a capacitor in the feedback loop. The feedback capacitor serves as the integrator and, by virtue of the negative feedback, pins the detector node to a constant voltage.

The first generation of CTIA readouts, CRC-696, was manufactured by Hughes/Santa Barbara Research Center for the multiband infrared photometer (MIPS) for the Space Infrared Telescope Facility (SIRTF) instrument. This device was a 1 x 32, single-gain, DC-coupled multiplexer, optimized for low photocurrents. A few of these devices, with and without IR detectors, were tested in the lab at Ames. The success of the CRC-696 led to the development of the next generation of these devices—the SB-190—with added features to expand and enhance their performance. The SB-190 is a 1 x 32, multigain, AC-coupled CTIA designed to accommodate a broad range of IR flux (including photocurrent levels consistent with airborne astronomy applications) (fig. 1). The multiple gain is achieved by having several integrating capacitors in the feedback loop that can be enabled in eight possible combinations.

These devices have been designed, developed, and characterized; their first application is intended to be for the far-IR detector array of the airborne infrared echelle spectrometer (AIRES), a facility instrument for the Stratospheric Observatory for Infrared Astronomy (SOFIA). To date, several of these devices have been tested; they showed adequate performance, although better performing devices are expected when the processing is refined and better controlled. The typical read-noise at the highest gain setting and with correlated double sampling is about 250 electrons. Further tests are under way, and this readout will be integrated with a 1 x 24 prototype Ge:Sb array in the near future.

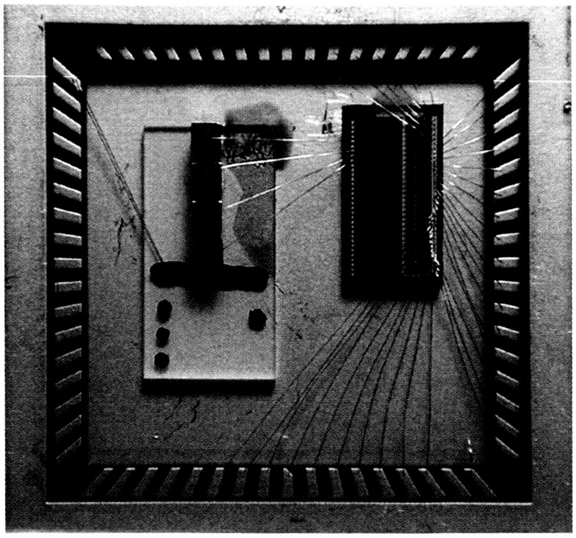

Fig. 1. A prototype 1 x 32 SB-190 multiplexer bonded to 4 Ge:Ga far-infrared detectors.

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Guide Star Telescope Detector Assembly for Gravity Probe-B

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Because of extensive experience in low-temperature detector and readout technology and the challenging technical and programmatic requirements, Ames is continuing to lead the development and manufacture of the guide star telescope detectors of the Gravity Probe-B (GP-B) Project. GP-B is a Stanford University/Lockheed Martin/Marshall Space Flight Center Physical Science mission. The scientific purpose of GP-B is to test Einstein's theory of General Relativity, which has been only partially verified and is one of the least tested of all physical theories.

The GP-B fine motion guide star tracking system uses a 5.6-inch-aperture, all-fused quartz telescope attached to a quartz block assembly containing the relativistic effect-sensing gyroscopes. The guide star telescope rotates about its central axis, thereby providing a constant pointed reference direction to a star that is fixed on the celestial sphere. This setup provides the critical inertial reference frame for the spacecraft. The satellite that contains this assembly, scheduled to be launched late in 2002, will be in a polar orbit about the Earth. The precession rate of the sensed gyroscope directional output from the inertial reference frame is a possible indication of a general relativistic deviation from that expected by Newtonian gravitational theory. A precession rate is expected to occur at a scale of a few arcseconds per year (arcsec/year), and it is expected to be measured with an accuracy of about 0.2 milliarcsec/year. For comparison, the apparent angular diameters of the few nearest stars, visible to all but the largest telescopes as points of light, are less than 10 milliarcseconds.